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Main article

An intelligent tutoring system for the accounting cycle: Enhancing textbook homework with artificial intelligence

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ABSTRACT

This paper describes an electronic tutoring system, developed using principles of artificial intelligence (AI), to help students learn the accounting cycle. Unlike other educational technologies, the tutoring system provides instruction and feedback that is tailored to each individual student and addresses not only problem-solving outcomes but also problem-solving processes. To assess the effectiveness of the tutoring system, we administered a pre-test and then required students in a sophomore accounting course to use either the tutoring system or their textbook as a reference when journalizing transactions for a homework assignment. We then administered a post-test. A pre-post analysis showed that the tutor group's test performance increased approximately 27% points, whereas the textbook group's test performance improved by only 8% points. Implications of these findings for instructors and researchers are discussed.

1. Introduction

Researchers in education, chemistry, physics, and mathematics have been working for more than a decade to develop electronic tutors that are built on principles of artificial intelligence (AI) (Anderson, Corbett, Koedinger, & Pelletier, 1995; Johnson & Holder, 2002; Merrill, Reiser, Ranney, & Trafton, 1992). As a result of these research and development efforts, students in these disciplines are now able to receive instruction and feedback that is tailored to their individual levels of understanding. In contrast, surprisingly few examples of AI-based tutors currently exist in accounting education. Even more

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scarce are examples of accounting education research empirically examining the effectiveness of AI-based tutoring relative to traditional forms of instruction, leading to calls for further research in this area (e.g., Bryant & Hunton, 2000; Goldwater & Fogarty, 2007; Mcvay, Murphy, & Yoon, 2007). The purposes of this paper are to describe an AI-based tutor that has been developed to provide instruction about the accounting cycle, and to report empirical findings that assess the impact of the tutor on student learning. The reported findings demonstrate the value of AI-based tutoring in accounting education.

Reviews of the accounting education literature (e.g., Bryant & Hunton, 2000; Rebele et al., 1998; Watson, Apostolou, Hassell, & Webber, 2007) describe AI tutoring systems as a new type of educational technology that has only begun to emerge in accounting. These reviews categorize AI tutoring systems with other computer-based educational technologies currently in use, including computer-assisted instruction (Handy, 2005), computer-based learning (Halabi, 2006; Halabi, Tuovinen, & Farley, 2005), computer-assisted learning (Mcdowall & Jackling, 2006), online homework management systems (Bonham, Deardorff, & Beichner, 2003), multi-media instruction (Mayer & Moreno, 2002), and hypertext linking (Crandall & Phillips, 2002).[1]

While classifying various forms of educational technology into a single category is useful for broad-based reviews, it blurs an important distinguishing characteristic of artificially intelligent tutors. Unlike all other computer-based education systems, artificially intelligent tutors respond *dynamically* to the individual learning needs of each student. That is, an AI tutor does not employ a set of "canned" instructions, guides, or problems that are pre-programmed to anticipate particular student responses. Instead, an intelligent tutor constructs responses in real-time using its own ability to understand the problem and assess student analyses. For example, an AI tutor can construct step-by-step feedback and hints that are tailored to the specific analyses and difficulties evident in each individual student's responses, much as a human tutor does.

This dynamic feature of an AI tutor, which is unique among educational computing technologies, provides many potential benefits over pre-programmed instructions and guides. Feedback is immediate, tailored, and targeted toward improving both the process and outcome of problem-solving. Provision of process-oriented feedback in particular represents a significant advance because prior accounting research finds that process-oriented feedback facilitates learning more than outcome feedback alone (Bonner & Walker, 1994; Halabi, 2006). In comparison to human tutors, which have been found effective in accounting (Jones & Fields, 2001), the AI tutor is available around-the-clock to provide tailored instruction and feedback for thousands of students.

Although AI-based systems offer potential benefits over other forms of instruction, they do not guarantee enhanced learning. Part of the challenge in creating an AI tutor is finding an appropriate balance between giving and withholding assistance (Koedinger & Aleven, 2007). Showing students how to solve a problem (giving assistance) can be effective in some cases, but requiring students to solve problems on their own (withholding assistance) can be equally effective in other cases (e.g., Halabi et al., 2005; Lindquist & Olsen, 2007; Schmidt & Bjork, 1992). Finding an effective balance between giving and withholding assistance has proven difficult in disciplines such as chemistry, physics, and mathematics. Many prior studies have discovered that even the best-designed intelligent tutoring systems in these disciplines have failed to enhance student performance beyond that demonstrated by students using a textbook to solve problems or answer questions during training (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; Evens & Michael, 2005; Katz, Connelly, & Allbritton, 2003; Reif & Scott, 1999). One lesson from this research is that we cannot simply rely on our intuition to judge the effectiveness of pedagogical innovation; empirical testing is required to support claims that the innovation is effective.

The research reported here makes two significant contributions to the accounting education literature. First, the research shows that artificial intelligence can be used to support accounting education in ways not previously discussed. Recent articles in accounting have shown that principles of artificial intelligence can be used to algorithmically generate limitless sets of numerical problems and cases on

[1] Bryant and Hunton (2000) and Thompson, Simonson, and Hargrave (1992) note that confusion and controversy surrounds the various labels that have been applied to subsets of computing technology.